Pushing the SCORM Envelope

The Role of XML, Content Management Systems,
And Dynamic Delivery in ADL-SCORM

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Executive Summary

The Advanced Distributed Learning initiative (ADL) emerged this year as a focal point for eLearning standards. Its Shareable Content Object Reference Model (SCORM) 1.0 technical specifications gained widespread acceptance and implementation among government, commercial, and academic circles.

SCORM represents the integration of all leading eLearning standards (AICC, IMS, IEEE, and soon Microsoft's LRN) to create a unified standard. SCORM seeks to enable reuse of Web-based content across multiple environments and products, as well as provide a means for individualized eLearning.

The goals of ADL are laudable. By promoting a digital knowledge network based on reusable objects and individualized learning, ADL believes it can help reduce the cost of instruction by 30—60%; reduce the time of instruction by 20—40%; increase the effectiveness of instruction by 30%; increase student knowledge and performance by 10—30%; and improve organization efficiency and productivity.

Further, the vision of ADL is consistent with that of many thought leaders in the eLearning and Knowledge Management industries - mainly, that true interchange of learning objects across disparate Learning Management Systems (LMS) will require adherence to accepted standards for describing learning taxonomies, course information, and course packaging.

However, we believe that SCORM must address three fundamental issues before the goals of ADL can be fully realized. These issues can be posed as the following three questions:

1. Will XML be prescribed as the data format for learning content itself?
2. Will a standard methodology be specified for integrating Content Management Systems with Learning Management Systems?
3. Will dynamic delivery of content objects be supported?

True reusability of learning objects requires a data format that separates content from its presentation; this fundamental requirement is met by XML. Learning Management Systems (LMS) provide only part of the solution for eLearning; XML authoring, Content Management Systems (CMS), and dynamic delivery round out the technologies necessary to complete the ADL vision.

As participants in the Technical Working Group for SCORM, Peer3 remains committed to supporting the ADL and the evolution of these important standards. Peer3 was the only vendor to present a commercially available eLearning solution for XML authoring, content management, and dynamic delivery at the first ADL PlugFest earlier this year. Now Peer3, in collaboration with other eLearning-oriented CMS vendors, is promoting the recognition of this distinct product category as well as changes to the SCORM that will result in open standards for XML-based eLearning content.

The groundbreaking work of ADL in unifying eLearning standards shows extraordinary promise. Early implementations of SCORM 1.0 during its first year of release demonstrate the commitment to open standards by virtually all leading providers of eLearning technology, content and service providers. While the current specification creates problems such as the "ransom note effect", mobile code security issues, network limitations, and learning portal constraints, SCORM 1.0 and the ADL initiative has succeeded in proving the basic concept of platform-independent learning objects.

SCORM 1.2 and 2.0 specifications have the opportunity to resolve the fundamental roadblocks to reusability if the ADL Technical Working Group acts on the recommendations of learning object pioneers in the public sector, and CMS vendors such as Peer3.

White Paper Goals

> *"The next vendor battleground in eLearning will be for control over the smallest chunks of content, those that capture individual moments of understanding. This will finally enable the technology for just-in-time learning and the convergence with knowledge management, and challenge the position of many current best-of-breed vendors."*
>
> - Clark Aldrich, Research Director and ELearning Core Topic Leader, GartnerGroup

The overarching purpose of this white paper is to identify problems and solutions related to SCORM 1.x in three basic areas: the use of XML, the role of Content Management Systems (CMS), and the need for dynamic delivery to achieve truly individualized learning. While a degree of familiarity with eLearning and related standards is assumed, this white paper is intended to address eLearning analysts, administrators, developers, and vendors who will influence ADL with results from their real world observations of SCORM-friendly technologies.

SCORM is a living document and is still in a trial implementation period. Current testing activity and demonstrations allow it to evolve and be refined into a more comprehensive and mature set of specifications. Version 1.0 of SCORM was released on January 31, 2000. Version 1.1 of SCORM (currently in review) addresses corrections, improvements, and clarifications to the original version. Future versions are expected to expand the initial scope of this work as technologies further develop and vendors begin to form alliances that achieve SCORM-based integration.

A draft of this paper served as a platform for discussion at the ADL PlugFest III, November 27-30, 2000. It is the intention of its authors to elevate XML, CMS, and dynamic delivery to the status of core revisions to be addressed in SCORM versions 1.2 and 2.0.

Currently, there are no certificate-issuing organizations responsible for certifying products determined to be conformant to the SCORM. ADL is in the process of establishing an accreditation program for certification of organizations. The authors of this white paper contend that future certification should be inclusive of XML-based content, CMS, and dynamic delivery.

It is the observation of the authors that SCORM has primarily had the benefit of academic, government, LMS and authoring tool vendor input. What has been deficient thus far is the real world experience of the private sector, as well as input from CMS vendors. American companies alone spend billions of dollars a year on the development of training products. Leading edge companies such as Cisco Systems with their Reusable Information Object (RIO) and Reusable Learning Object (RLO) strategies have pioneered the practical use of XML-based content, CMS, and dynamic delivery, *in addition to* LMS and authoring tools to reduce the costs associated with training development. Their real world experiences with these technologies and strategies should be considered before SCORM takes shape as a set of standards for practical use.

This white paper will illuminate some practical implementations of reusable learning objects in the private sector in order to widen the field of best practices that go into shaping the next versions of SCORM. While SCORM 1.x makes reusable learning objects *technically* possible, the current specifications make *practical* implementation difficult for reasons that will become clear in the body of this white paper. By shedding light on the practical deficiencies of SCORM 1.x, the authors seek to help the eLearning industry as a whole to avoid premature standardization and the rejection by end users of static "courses" assembled from these ill-defined reusable learning objects.

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ADL Values (the "abilities")

ADL partnerships between the Federal government, private-sector technology suppliers, and the broader education and training community promote voluntary guidelines that will meet common needs. The ADL initiative seeks to ensure that academic, business, and government users of learning software gain the best possible value from the materials they purchase. According to the ADL, this overall value may be obtained when eLearning content achieves a consistent degree of *reusability, accessibility, interoperability, adaptability, durability,* and *affordability*.

By mapping the individual ADL values to the SCORM 1.x correlatives, we can identify problem areas from the standpoint of practical implementation that may be addressed by the inclusion of XML-based content, CMS, and dynamic delivery. The quotes that begin each of the following sections are taken directly from the SCORM Version 1.0 document, dated January 31, 2000.

Reusability

> *"The design of instructional components so that they can be incorporated into multiple applications."*

Implementation of SCORM 1.x by authoring tool and LMS vendors demonstrates the basic concept of learning object reusability. We can sequence static objects, serve them with an LMS, and even track student results without platform dependencies. However, reuse is hampered under the SCORM 1.x because it is possible to sequence objects together that have different look-and-feel and style definitions, different navigational controls, and different instructional design methodologies, sizes and densities.

The net result of this type of reuse creates a "ransom note" effect in its practical implementation.

$$R_{A}N_{S}O_{M} \; N_{o}te$$

Reuse is possible without the ransom note effect when the content of the learning object meets the following criteria:

1.   Presentational control (look & feel and style) external to the content.

A key aspect of reuse is the ability to present the same content in multiple formats, in multiple contexts, and in multiple presentation formats without having to change the content. This is enabled when the content is pure XML where presentation is defined separately from content. This allows objects authored for different purposes to be sequenced together while presenting a consistent look and feel.

2.   Separation of services from the content

Navigational control, assessment, progress, index, search, etc., are encoded in descriptive XML. The runtime environment interprets this data and provides the intended functionality. This assumes that there are standards for data models and specifications for how systems are meant to use the data. Much of this work is well underway in the IMS standards community where data models are being forged for content packaging, questions and tests, and profiles.

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A good example of this concept is demonstrated in the IMS Question and Test specification where questions and tests are modeled in XML. The runtime engine interprets the services of rendering the questions and controlling their behaviors.

Like questions and tests, we believe that the SCORM should move rapidly to include an XML data model for content.

3.   A set of best practices for the design and structure of content

In the commercial world, companies exploring reusable learning object technology have discovered that for reuse to be successful there must be consistency in the structure, style and design methods used to create the objects.

The Department of Defense (DoD) and other Federal agencies seek to make use of commercial eLearning best practices. One of the best examples of an early commercial implementation comes from Cisco Systems, the world's largest provider of internetworking technologies.

Cisco recognized the need to move from creating and delivering large inflexible training courses toward creating database driven objects that can be reused, searched, and modified independent of their delivery media. Their Reusable Information Object (RIO) and Reusable Learning Object (RLO) Strategies began to take shape in 1998. Using this methodology, Cisco has created thousands of Reusable Learning Objects, using a variety of technologies, to create eLearning products for employees, partners, and customers. Their experience offers ADL a wealth of best practice information.

The RIO/RLO specification offers an instructional design methodology and content model that combines:
- Performance-based instructional design methodology
- Modified Information Mapping content structure
- Information Management System (IMS) metadata
- XML data format for content

Following these tenets, Cisco has enforced design and structure standards across a worldwide authoring population and successfully has created reusable learning objects.

4.   An object model granular enough to support reuse of small document components.

To achieve the stated goals of the SCORM for small sharable objects such as images, audio, video, text, and simulations, the learning object model must reflect a high degree of granularity. Every object, from leaf-level text and media objects, to the container objects that hold them should be reusable. A truly object oriented system allows for parent objects to point to their children by reference to a unique id. Child objects are capable of being pointed at (reused) by multiple parents.

In SCORM 1.x, a single URL represents the content of an assignable unit (AU), thereby creating no opportunity to reuse the components of that content, or to dynamically adjust the content delivery at a more granular level than the AU.

Practical field use of RIO/RLO technologies by Cisco has revealed the need for granular reuse because learning objects often require slight modification when placed in new contexts. To avoid wholesale copy of an object, reuse of small document components allows an author to reuse as much of the original objects as possible with a minimum of redundancy.

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Accessibility

"The ability to access instructional components from one remote location and deliver them to many other locations.…"

… "The ability of a web-based LMS to launch 'executable' content authored using tools from different vendors and to exchange data with that content."

While accessibility is a stated goal, the SCORM 1.x actually relies on executable content that is inaccessible through most firewalls. Executable content is an extreme security hazard and is prohibited by most firewalls – and for good reason. The end-user has no way of knowing what will happen when executable code is launched. Under the SCORM 1.x model, it is entirely possible to sequence assignable units (AUs) that contain malicious code. Ironically, the DOD has strict firewall policies that would not allow some SCORM "conformant" content to pass. In fact, SCORM content is required to contain JavaScript code and a Java applet whose functionality is likely to be rejected by a strict firewall.

To achieve accessibility through secure firewalls, content must be purely descriptive, devoid of any executable client-side code (i.e. executable content, calls to plug-ins, JavaScript, java, etc). It is our opinion that the SCORM 2.x should include a purely descriptive content model with an XML binding. A pragmatic choice could be XHTML, which conforms to a W3C-approved schema for representing HTML as XML.

Another factor that limits accessibility is the communication between content and the LMS. The 1.x implementation of the SCORM relies on JavaScript for communication with the LMS. The problem is that Internet Explorer imposes security restrictions that make it difficult, if not impossible, for JavaScript to communicate with an LMS that does not reside on the server from which the content was downloaded. Java applets are likewise restricted in this manner, able to access only the server from which they were downloaded. The net effect of these restrictions is that the learner can only access content that resides on the same server as the LMS.

To address accessibility concerns with respect to LMS-content communication, Peer3 recommends investigating a solution that addresses the following requirements:

- The LMS must be capable of accessing content across most firewalls
- Learners must be able to access content anywhere on the Internet
- There must be a mechanism to authenticate that exactly one user receives that content
- There must be a mechanism to authenticate that the content being accessed is the authorized version of the object from the authorized publishing agent
- There must be a consideration of intellectual property and e-commerce

Based on this set of requirements, the apparent properties of the solution should include:

- No client-side executable content
- A URL-based communication initiation (servers may communicate with each other through a different mechanism, but the handshake should be URL-based)
- Server to server communications should be XML-based
- Must accommodate but not require authentication of learner, content publisher, content distributor (delivery system), and initiator (LMS)
- To be accepted by users, it must pragmatically use widely adopted standards

Interoperability

> *"The ability to use instructional components developed in one location with one set of tools or platform in another location with a different set of tools or platform."*

The ADL was correct in recognizing that leading edge organizations are collectively embracing platform neutrality and an object-based approach to information design, as well as software systems architecture. The push for platform neutrality can be seen in the acceleration of software development based on open standards such as XML, Java, and Linux.

With the push toward platform neutrality comes object-based design models for both information and software. Platform neutral objects may be reused in different contexts and environments to create new combinations from existing data; this approach significantly reduces the time and expense of original development. ADL ultimately seeks to define a platform neutral object model for eLearning, but the SCORM 1.x specification has stopped short of true interoperability.

According to the current ADL Website www.adlnet.org, "There is an emerging consensus that specifications for new platform-neutral techniques are sufficiently mature to justify investment in next-generation applications. While it is understood that more innovation is needed in the education and training domain, it appears that the development of a robust, object-based, and platform-neutral environment for distributed learning will become practical and feasible over the next 2—5 years."

In fact, the software industry is much closer to making this environment a reality than ADL might realize. By focusing on what legacy authoring tool and LMS vendors could immediately provide in terms of a solution, the SCORM 1.x specification overlooks what CMS vendors can provide today through XML-based content and dynamic delivery.

Content management systems organize enormous numbers learning of objects in a database (or federation of databases) for easy search and retrieval. Depending on the level of sophistication, a CMS may store these learning objects in a highly molecular fashion, associating metadata with the smallest components of these objects. Leading CMS vendors are beginning to discuss practical methods for descriptive content interoperability between competitive systems in order to advance the larger agenda set by ADL.

If ADL shifts its focus toward descriptive (XML-based) content, and includes CMS and dynamic delivery with existing authoring tool and LMS technologies, the specifications for a robust, object-based, and platform-neutral environment for distributed learning will result.

Adaptability

> *"The longer term expectation of ADL is to encourage technologies that enable so-called dynamic learning where content is custom-assembled and delivered to learners according to their own personal pace and need."*

ADL's desire for adaptability of the learning experience is reflected in the *Department of Defense Implementation Plan for Advanced Distributed Learning,* issued by the Office of the Deputy Under Secretary of Defense (Readiness), dated May 19, 2000. That report states that ADL shall "…provide adaptable learning tools and content that can be tailored to the needs of the individual learner on the fly."

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While CMS products using dynamic delivery engines to serve up customized eLearning experiences are on the market today, SCORM 1.X does not address adaptability. Personalization technologies are widely used in commercial web sites like Yahoo, My Excite, Amazon.com and Barnes and Noble. This technology is neither new nor cutting-edge in the year 2000.

To fully achieve its goals of adaptability, the SCORM specification should address the interplay of the user profile, profile servers, XML-based content, content repositories, and delivery servers.

Durability

> *"Instructional components that do not require redesign or re-coding to operate when base technology changes."*

For anyone who invested in 8-track or Betamax cassette devices and content in the 1970s, the issue of durability for electronic data formats is of prime concern. Far from improving the longevity of content, the electronic revolution has created a rapid form of entropy – that being the inevitable heaping of last year's or last month's hot technology on the dustbin of history. The rate of obsolescence is nowhere more apparent than in computer technology, where competing data formats, even within the same product line, are making digital compost of our precious information.

Vendors of authoring tools for computer-based training (CBT), saddled with elaborate applications built on legacy fourth generation languages, began their push toward eLearning by "Webifying" these proprietary file formats through the use of plug-ins for the browser. As users of plug-ins can testify, chances are good that before you can enjoy that next interactive, animated, sound-sculpted, splash effect, you will first be thrust onto some software maker's Web site to download and configure their latest plug-in.

Because of past commitments to CBT developed in legacy systems, the original participants in defining SCORM focused predominantly on creating a mechanism to protect their investment in executable, proprietary formats during the rapid shift toward an economy of learning objects. This emphasis on supporting proprietary formats by "surrounding" these content objects with IMS metadata records and a Course Structure Format (CSF), both written in XML, renders SCORM 1.x low on the durability scale. A major hazard with executable (versus descriptive) content is the durability of that content over time. With changes in the browser and operating systems, executable content runs the risk of becoming unsupported with each incremental change to the client platform.

Since XML is an open, Web-centric standard drawn from a mature and comprehensive text markup language (SGML), it is the ideal foundation upon which durable content may be developed. In fact, the IMS makes extensive use of XML in defining many aspects of reusable learning objects, including their constituent metadata.

Affordability

> *"To meet the expense of, or provide to others without economic burden…"*

Computer-based training materials are largely developed on a proprietary, company-by-company basis, resulting in high development costs and limited resale value. The ADL initiative is designed to accelerate large-scale development of cost-effective learning software and to stimulate an efficient market for these products in order to meet the education and training needs of the military and the nation's workforce in the 21st century.

A symbolic step in the right direction was taken recently by the ADL when it changed the meaning of the SCORM acronym from Shareable *Courseware* Object Reference Model, to Shareable *Content* Object Reference Model. This subtle change suggests that the ADL recognizes the potential marketability of individual learning objects that may be resold with or without the original "course" level aggregation.

This type of object-based usage presents significant new business challenges that must be addressed, as acknowledged by the Office of the Deputy Under Secretary of Defense (Readiness) in the May 19, 2000 publication *Department of Defense Implementation Plan for Advanced Distributed Learning*. That report states that, "If learning objects are to be shared, reused, and marketed, we must protect intellectual property rights. If we are to take full advantage of such technologies, we must fundamentally change how we do business; and this means we must change organizational structures, reengineer budget processes, and provide incentives to enable and motivate change."

A clear indication that ADL embraces the concept of a "knowledge object economy" is the inclusion of all IMS metadata as part of the SCORM data model; this metadata offers registration of intellectual property through values such as "Rights," "Cost," "Copyright and Other Restrictions," etc. However, as implemented in SCORM 1.x, intellectual property protections are compromised which therefore limits affordability by the providers of original content.

As described in the previous section on accessibility, SCORM 1.x relies on a schema that promotes the electronic duplication of materials from server to server. This duplication is necessary to meet the criteria that content must reside on the same network device as the LMS. Meanwhile, the IMS metadata containing ownership information is stored as a separate XML file from the executable content. The LMS is not required to maintain the association of content to its metadata, thereby encouraging the loss of intellectual property rights as content is copied from one server to another.

In a true knowledge object economy, objects should have unique identifiers, and the electronic transfer of content from one server to another is discouraged in favor of network delivery where the host CMS can maintain a "use log" for content being accessed from other machines.

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The Case for inclusion of an XML-based content data model

In SCORM 1.x, content is opaque and undefined. The CSF merely points to a URL that launches executable content. As detailed in this white paper, reliance on executable content creates many violations of the basic "abilities" defined in the ADL charter.

A pure XML-based content model that relies on runtime services to render the presentation in multiple formats is needed in SCORM 2.x. The precedent of the IMS question and test specification (QTI) paves way for an XML data model for content. The QTI specification details the presentation and behavior of questions in XML and relies on the server to provide runtime functionality.

Peer3 advocates the adoption of an XML-based data model to describe content. The advantages of this approach provide the following benefits:

- XML, based on long-established SGML, is a lingua franca with huge adoption. There are an increasing number of tools to support it.
- XML is secure because it is totally descriptive and devoid of executable code
- Intellectual property encoded in XML is system independent
- XML is easily transformed. This provides insurance that content developed can keep pace with evolving standards like SCORM.
- XML overcomes the ransom note effect – content and presentation are separated
- XML may import and export between systems
- XML content is ideal for database and content management because document components facilitate granular reuse

The Case for CMS

SCORM 1.x describes the domain of eLearning in a simple duality: content and LMS, where LMS is a catchall for all eLearning software services. This conceptual model casts confusion in the market because it promotes head-to-head competition among would be collaborators. A technical evaluator might be confused when asked to evaluate two systems lumped in the LMS category, where one system's strength is training resource management (e.g. scheduling classrooms and instructors) and the other system's strength is content management of learning assets. The current rubric predisposes inappropriate comparisons among such systems.

For the SCORM 1.2 specification, the solution to this ambiguous definition is to clarify references to LMS and include specifications for discreet data models and software functionality. This will offer the ADL consumer the means to make rational comparisons and assemble a best-of-breed system architecture that suites specific needs. Much of this work is currently being done in the IMS.

A major component of advanced eLearning architecture is an object-based content repository (i.e. content management system, or CMS). The repository is the central place where metadata-tagged chunks of educational content are stored. An authoring interface to this repository allows for the authoring and assembly of the small chunks into larger aggregates of training such as learning objects, modules, courses, etc. Dynamic delivery engines can draw upon this learning content to assemble personalized learning on the fly. Without a CMS, the aspects of adaptability and reusability are limited.

To achieve the ADL vision, we believe that it is vital that SCORM 2.0 include CMS in its architectural philosophy.

The Case for Dynamic Delivery

The ADL vision describes a personalized, just-enough, just-in-time, adaptive learning experience. To achieve personalization under SCORM 1.x, the logic for personalization must be embedded in the content itself. When integrated with a CMS, a dynamic delivery engine assembles a customized training experience on the fly that adaptively assembles content from a pool of granular, reusable objects.

With an eLearning architecture that includes CMS functionality, XML-based content, XML-based authoring, and a dynamic delivery engine, it is possible to separate content presentation and runtime services from the content itself. With the runtime services of presentation and navigation controlled by a server, the system can assemble a truly personalized learning experience.

Peer3 and SCORM 1.0/1.1

Peer3 meets the SCORM 1.0 specification in two ways. The first way is by exporting static HTML and then embedding the SCORM API adapter applet and JavaScript wrapper.

The second approach uses the SCORM JavaScript adapter as a point of systems integration between an LMS and the Peer3 Dynamic Delivery engine. The LMS uses API calls to launch a dynamically delivered course from a Peer3 Repository. The API adapters are added to the pages on the fly. Then the API passes data between the LMS and the Peer3 engine to get and set student data. In effect, we use the API as a means to introduce repositories and dynamically delivered content into the SCORM architecture.

The second method points up the need for a standard way to integrate with the LMS. Peer3 developed this second implementation to illustrate system-to-system level communications between a SCORM-conformant LMS and a SCORM-conformant CMS. While this method provides more versatility and reusability than the static first method, there are problems inherent with meeting the current SCORM 1.x specification. Specifically, SCORM requires the use of applets and JavaScript for content (Assignable Units) to communicate with the Learning Management System. Unsigned JavaScript and applets have the aforementioned restriction of communicating only with the server from whence they were downloaded; therefore, the API adapter may be recognized only if it resides on the same system as the content. Likewise, once the API adapter is found, it can only communicate back to the same server as the content.

To get around this restriction, Peer3 resorted to low-level network remapping to trick the browser into believing that the content and the LMS are on the same server. This solution will not work on the general Internet because no single learning portal has (nor should have) the authority to perform this remapping for the Internet at large.

Conclusions

The ADL-SCORM initiative has taken important steps toward advancing workable standards for interoperability of learning content across learning management systems. ADL is to be commended for achieving real progress toward this goal by focusing on increased reusability, accessibility, durability, adaptability, and affordability of Web-based learning content.

However, SCORM does not yet adequately address several issues that will become increasingly critical in achieving the lofty goal of reusable learning content. We believe that the most critical issues to address are:

- Prescribing XML as the data format for content
- Providing a standard methodology for CMS/LMS integration
- Addressing the need for targeted learning through dynamic delivery of content

We look forward to exciting days ahead for eLearning as SCORM considers and addresses these and other issues.

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